Coping and resilience in riverine Bangladesh[1]

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Abstract

This paper investigates the impacts of two successive years of severe floods on households, their coping strategies and resilience to riverine hazards in northern Bangladesh. Based on focus groups and interviews with the same households after floods in 2016 and 2017, we found a cumulative decline in assets through sale of livestock and borrowing, and almost all households evacuated short term to higher places. Three notable recent ways that vulnerable households use socio-hydrological landscapes to enhance their resilience to hazards were revealed. Firstly, local flood protection embankments were the main destination for evacuation and were highly valued as safe places, although they breached and failed to protect the land. Secondly, community organisations, formed mainly for livelihood enhancement, took initiatives to provide warnings, to help households relocate during floods, and to access relief and rehabilitation services. Thirdly, seasonal migration by men, particularly to urban areas, is an important element of long-term coping and resilience based on diversified livelihoods for about 70% of these rural households. Although the unintended use of infrastructure, social capital and urban opportunities all form part of coping and resilience strategies in hazardous riverine landscapes, the high mobility that they are based on is not supported by enabling policies.

Key words: Bangladesh, erosion, flood, infrastructure, migration, socio-hydrology

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1 Introduction

This paper uses evidence from two recent years of exceptional floods (2016-2017) in a riverine area of Bangladesh to understand how vulnerable households use infrastructure, institutions and urbanization to cope with hazards. Hydrological science has recently sought to take a more integrated view of societal interactions with floods (Sivapalan et al., 2012). This has been termed socio-hydrological, derived from the field of study and practice termed socio-hydrology, and is taken here to mean interdisciplinary study of the dynamic interactions and feedback between water and people. Arising from hydrologists the concept as recently adopted has a modelling focus that aims to capture the full range of human behavioural interactions with water resources. However, it can be argued (Wesselink et al 2017) that socio-hydrology is a recent water system based incarnation of the much longer established field of socio-ecological systems (Berkes and Folke 1998), which itself brought together aspects of systems approaches, human geography and institutional analysis related to natural resources. By contrast the concept of hydrosocial systems has its foundations in human geography with an emphasis more on hydrological cycles and analysing power relations (Linton 2008; Wesselink et al. 2017). To empirically ground socio-hydrological propositions, Ferdous et al. (2018) put forward the concept of socio-hydrological space as a geographical area in the landscape with distinct hydrological and social features that give rise to the emergence of distinct interactions and dynamics between society and water. In Bangladesh these spaces are distinguished by differing exposure to flood and riverbank erosion, delineating the active but inhabited floodplain from adjacent embanked lands (Ferdous et al., 2018). This paper shows that a riverine landscape that includes different socio-hydrological spaces is itself nested within, and increasingly dependent on, wider socio-economic institutions and systems, since people and water in rural and urban areas are becoming more and more connected. We find that people are more mobile than has been characterised in previous studies. Undoubtedly there is a strong attachment of rural people to home (village) locations, but there is evidence that those vulnerable to floods are not ‘immobile’ or ‘trapped’ where they currently live (Foresight, 2011). Rural people may take up work in urban areas while retaining a foothold in their floodplain origins. Urbanization and inter-district communications in Bangladesh have developed at a fast pace. Also, the establishment of many community based organisations (CBOs) in recent years has changed the situation of rural people bringing opportunities to help them withstand hazards. This paper enriches these insights on recent socio-economic developments affecting life in flood-prone rural areas in Bangladesh.

Bangladesh is one of the world's most flood prone countries. Floods occur due to storm surges associated with cyclones in the Bay of Bengal affecting coastal areas, heavy rain over adjacent hills causing flash floods, and monsoon rains over the Ganges-Brahmaputra catchment that cause extensive riverine floods. Up to 80% of Bangladesh comprises of floodplain (Brammer, 1990), and about 25-33% of the country remains under water every year for 4-6 months during the monsoon (rainy season). 'Normal' floods have limited negative impacts and are even considered beneficial to agriculture, but the situation is very different in extreme floods (Paul, 1997). For example, in one of the last major riverine floods in 1998 about 60% of the country was flooded, about 1,000 people died, about 2,000 km of embankments were damaged and losses were valued at up to US$ 2.8 billion (Brammer, 2004). In addition, riverbank erosion causes loss of land and infrastructure almost every year.

Although evacuation in response to cyclones and coastal flooding has been well studied in Bangladesh (reviewed in Penning-Rowsell et al., 2013), riverine floods and erosion lead to different responses due to the nature of the losses, the physical features of the area affected, and its settlement history. Superimposed on long established hazards is a new popular discourse on climate change impacts which perceives large scale migration as a potential source of instability. This has raised alarms for Bangladesh with fears of large scale human displacement and mass migration from coastal areas which are predicted to become more regularly inundated by increasing sea levels (Mirza, 2002). With Bangladesh's high population density and high levels of poverty, the consequences of climate change for human life and society are often portrayed as cataclysmic and potentially leading to unmanageably large numbers of 'climate refugees' (Salauddin & Ashikuzzaman, 2011; Ahsan et al., 2014). However, recent studies highlight the dynamic nature of the Bangladesh delta where major sediment deposition interacts with embankments to create waterlogged polders (Auerbach et al., 2015). Sedimentation may mitigate displacement of many people, while the impacts of a slowly-rising sea-level are less than those generated by increasing population pressure on natural resources (Brammer, 2014). Moreover, detailed studies reveal that drivers for migration are more complex and include several push factors such as environmental changes (Joarder & Miller, 2013; Penning-Rowsell et al., 2013; Etzold et al., 2014; Yasmin & Ahmed, 2013).

Since the 1960s flood mitigation in Bangladesh has been based on a structural approach of large-scale embankments constructed by the government. In the 1990s recognition was growing of adverse environmental and social effects of embankments that counteracted their benefits (Thompson & Sultana, 2000). Civil society debate grew over flood control and

requirements for local participation and environmental mitigation, which challenged the technical-engineering dominance of policy (Sultana et al., 2008). Public participation in water resource management in Bangladesh was formally adopted (Ministry of Water Resources, 2001), but active local participation in managing water is most often in smaller scale systems where communities manage irrigation and local leaders tend to dominate decisions (Sultana & Thompson, 2010). Studies on participatory water management in Bangladesh have reported local people collectively repairing damaged embankments (Penning-Rowsell et al., 2013), while Yu et al (2017) focused on idealized community initiatives to protect public infrastructure. However, these are exceptions rather than the norm, and practical public participation in larger scale flood mitigation is limited (Dewan et al., 2015).

Despite engineering works, floods and riverbank erosion still cause substantial damage to land, crops, houses, and properties (Thompson & Tod, 1998; Islam et al., 2012; Ayeb-Karlsson et al., 2016). Each year several thousand people become homeless and landless due to river bank erosion (Haque, 1988; Haque & Zaman, 1993; Indra, 2000; Hutton & Haque, 2004). Households living along the main rivers have to face the costs of frequently repairing or constructing new houses due to floods and riverbank erosion, which adds to their existing burdens (Yasmin & Ahmed, 2013). In the major floods of the 1970s and 1980s floods were a route to households falling into debt and impoverishment (Alamgir, 1980; Haque & Zaman, 1993).

Households who have lost both homestead and any cultivable land they owned due to riverbank erosion generally shelter on other people's land or on public land (including embankments) close to their original homes (Baqee, 1998; Elahi et al., 1991; Rahman, 2010; Gray & Mueller, 2012; Joarder & Miller, 2013). The majority of flood affected people try to stay near their houses in the hope that land may accrete along the river so that they can reclaim it (Mamun, 1996; Brouwer et al., 2007). When these hopes are not fulfilled, they may then migrate to other districts where land or work might be available. Only a few migrate permanently to towns and cities (Haque, 1988; Joarder & Miller, 2013; Indra, 2000; Gray & Mueller, 2012; Ayeb-Karlsson et al., 2016).

This study updates knowledge and understanding of coping and resilience strategies in a changing socio-economic context, with a focus on how households use temporary evacuation and seasonal migration between rural flood prone areas and urban areas. It also examines the role of local community based organisations (CBOs) in strengthening resilience, and the role of structural flood mitigation (embankments) in connecting unprotected and protected socio-hydrological landscapes.

2 Methods

2.1 Study sites

This study focuses on three districts of northwest Bangladesh (Fig. 1). The Jamuna–Brahmaputra River[i] in this area has been widening and shifting its course since 1830, becoming braided. During 1973–2000 satellite images showed it widened by about 128 m per year (EGIS, 2000). River erosion affects lands that have been settled for generations and also the *chars* (islands of accreted sediment) within the braided river. In each of the three districts three unions (the lowest administrative tier) were purposively selected to represent differences in exposure to riverine hazards and structural flood protection, and because CBOs were known to be active there.

Gaibandha District, the most southerly of the three districts covered, is situated to the west of the Jamuna-Brahmaputra River, with part of the district behind the Brahmaputra embankment and part in the riverine chars. The three unions studied represent lands stretching from the embankment out into the river: Gazaria Union includes a branch of the river and associated fishing communities; Kapasia Union, where most people live on the embankment or on land between the embankment and the river channels; and Kamarjani Union which mainly comprises chars.

Kurigram District, immediately to the north of Gaibandha, includes the most northerly reach of the Brahmaputra River within Bangladesh. Here the unions selected mainly represent chars separated from the mainland by branches of this braided river. Panchgachia Union borders the Brahmaputra and Dharla Rivers with some embankment-protected land and the rest is chars; Begumganj Union lies entirely in the riverine areas outside of embankments, and Jatrapur Union almost entirely comprises chars.

Lalmonirhat District, to the west of Kurigram, is located along the Teesta River just upstream of its confluence with the Brahmaputra River. The Teesta has a relatively narrow floodplain bordered by embankments on both sides. The study sites represented primarily mainland areas that have not accreted or eroded in recent times, protected by embankments from normal floods. The three unions are: Bhelabari Union located behind the Teesta embankment and equidistant from the Teesta and Dharla Rivers; Tushbhandar Union which is bisected by the Teesta embankment and has some unprotected land; and Rajpur Union

where the Teesta River flows through the middle of the union, and active erosion of village land is common, but also with some embankment protected areas.

2.2 Data collection

In these nine locations flood impacts and inhabitants' responses to floods and riverbank erosion were investigated initially through focus group discussions. Subsequently, surveys in one union in each district were undertaken. These unions were selected for their different exposure to flooding and riverbank erosion: an island char within the braided river with the highest exposure (Jatrapur Union in Kurigram district), a settlement on the embankment and adjacent riverside land with some exposure (Kapasia Union in Gaibandha district), and a village protected by embankments with least exposure (Rajpur Union in Lalmonirhat district). The survey focused on experiences during and after unusually severe floods in 2016 and 2017. We initially investigated the impacts of floods and erosion in 2016, and when 2017 also produced extreme flooding we repeated the surveys. In each of the three unions, within an area where CBOs were active, 40 households were randomly sampled. The head of household was interviewed in 2016, and the 107 households that remained in the three areas were re-interviewed in 2017, in both years during November soon after the flood season.

3 Results

3.*1 Past flood experience and general economic trends*

All respondents in the household survey had experienced floods and riverbank erosion during their lifetimes, and all respondents had moved home at least once. The recollection period by definition varies between respondents due to age, 58% of respondents were 31-50 years old so their memory extends back to at least 25 years. Their past experience of moving home due to flood or erosion is likely to influence coping strategies. Most households had moved home 2-8 times in their lifetime (Fig. 2). The number of moves was associated with location (X^2=23.2, df=6, $p<0.05$), households had moved fewer times in Gaibandha, whereas even those currently living in locations at low erosion risk in Lalmonirhat were found to have moved there due to frequent river erosion elsewhere.

The households had recent experience of floods. Over the previous five years (2011-2015) 95% of surveyed households in all three study unions reported that they had experienced

floods affecting their homes, with almost all also reporting loss of work and serious illness associated with floods. On average in all three unions households had experienced two damaging floods in those five years. Most households had also been affected by erosion in one of these five years, although this varied between locations with the Gaibandha households worst affected (88% lost land and 83% lost housing to river erosion) compared with Kurigram (73% lost land but only 43% lost homes) and Lalmonirhat (65% lost land and 50% lost homes). Almost 80% of respondents believe that the incidence of floods and erosion is increasing.

During 2011-2015 the surveyed households reported that their net incomes had increased, based on the trends (increase, no change or decrease) that they reported for four main categories of possible income (agriculture, livestock, wage labour, seasonal migration). Differences between unions were consistent with differences in hazards, with the households in the most exposed union having the lowest incomes. In Lalmonirhat a majority of households reported that income from crop agriculture increased. Incomes from livestock rearing also increased; this is an important strategy in these areas where in the dry season there is plentiful grazing in the chars and cattle can be moved to the mainland before floods strike, and is discussed further in section 3.3. Most households also reported increases in their income from local wage labour. In addition, 55-70% of households said household members undertook seasonal migration for work in the past five years involving more days worked and increasing wages. Over half of the households in Gaibandha and Kurigram reported that they had improved their house structure in this period. The resulting increase in total household asset value was diminished by declining landholdings in all three unions, with over 75% of respondents reporting that their landholding had declined, mainly due to erosion. Although incomes have increased, so have living costs, and hazard events in the same period caused loss of assets, which explains why about 80% of households reported running down their savings. Hence immediate coping ability may have been enhanced by rising incomes, but the implications for long term resilience were unclear. The cumulative impacts of unusual floods in two successive years – 2016 and 2017 on resilience were a subject of investigation.

3.2 The 2016 and 2017 floods

In the whole study area the 2016 and 2017 floods were more severe than recent years. The 2016 flood in Bangladesh in the Brahamputra and its tributaries was estimated at the time to have a 1-in-100 year return period. In 2016 the water level at Bahadurabad gauging station (located in this area) exceeded the previous highest ever recorded water level of 1988

(Islam, 2016), but this level was exceeded again in 2017. The return period of the 2017 flood peak has been estimated as 1-in-30 to 1-in-100 years, but both estimates of return periods are affected by the short length of data series and changes in river morphology as well as uncertainties introduced by climate change (Sjoukje et al., 2018). In both years flood peaks occurred in both July and August. The flood peaks were relatively short in both years since they did not coincide with high flows in the Ganges, nor with spring tides in the Bay of Bengal.

From the focus groups data it appears that in 2016 in Lalmonirhat only about 8% of the 20,000 households in the three unions had flood damage to their houses, fewer than in the other districts, and the affected households evacuated to embankments for about two weeks. In Gaibandha about 70% of 4,300 households in the three unions were flooded, in some areas because embankment breaches occurred; the majority of those affected moved for up to a month to embankments or to protected areas. In Kurigram about 56% of 8,700 households in the three unions were estimated to have been flooded. In this district evacuation responses varied between locations: those affected by erosion evacuated to embankments, but many people sheltered on and near their homes. In 2017 all surveyed households in all three areas were flooded and temporarily evacuated, mostly to embankments. In 2017 erosion impacts were more severe than in 2016 in the unions in Lalmonirhat and Gaibandha districts, where almost half of the households lost some or all of their homestead land. Most households stayed in the area at the time of the surveys hoping that their land might reappear from the rivers, but a few households were reported to have already left the area permanently.

In 2016 up to 50% of houses were damaged in the floods, with widespread loss of poultry and some other livestock. In addition, most households lost income as daily labouring work was neither available nor possible locally, and they were busy coping with floods so could not look for work. The average reported losses per household in 2016 were about US$ 168 in Lalmonirhat, US$ 228 in Gaibandha and US$ 303 in Kurigram. Given the severity of the 2017 floods, losses were likely to have been higher, although some households had fewer assets to lose because they could not recover from 2016, and detailed data was not collected as the follow up survey focused more on migration.

Ill-health was widely reported in both years' floods. This was a greater problem in the unprotected areas, particularly the chars (Table 1). In 2016 70% of households lost on average 16 working days per household due to illness during the floods and spent almost US$ 37 per household on treatment. In 2017 households also lost on average about 16

working days per household due to illness during the floods. In 2017 they spent about US$ 50 per household on treatment, with higher costs in Kurigram and lower costs in Lalmonirhat.

3.3 Responses to floods

3.3.1 Range of coping actions

Households were asked what actions they had taken to cope with floods and riverbank erosion in 2016 and 2017. The incidence of coping actions reported was generally similar in the three unions and in the two years (Fig. 3). In all three unions all households changed their eating practices to cope in both years, reducing the number of meals and amount eaten, and ate lower quality or less preferred foods. Moreover 70% of households in 2016 and over 80% in 2017 borrowed food in addition to food aid that most of them received. A minority of households did casual labouring work for food in 2016; this increased in 2017. Very few households pledged labour for advance payments or sold expected harvests in advance. Both of these practices often lead to indebtedness.

Ownership of livestock can strengthen resilience, but also has disadvantages as an adaptation. Animals are movable and can be sold to raise cash, but are vulnerable to drowning and ill-health, also access to safe shelter during floods in the char areas was reported to limit their role in coping. Participants in a focus group in Gaibandha after the 2016 floods emphasised some of these vulnerabilities: “There was no shelter for livestock in the chars during the flood, even though there was sufficient livestock feed. So we were forced to sell livestock. The char area had lots of buffalo before, but now the number decreased to almost none due to lack of space and feed. But the number of milk cows increased as a way of coping with flood risk.” In this area char households can sell milk to inhabitants of the protected ‘mainland’, revealing linked livelihood strategies between these areas. Livestock sale is to some extent forced upon households in the unprotected riverine landscape, but in 2016 sale of livestock, particularly goats and poultry, was also a common coping action. Challenges to feed cattle and move them to safety were reported to have been greater in 2016 than in previous years. In 2016 the Muslim festival of Eid-ul-Azha took place in September, in the late monsoon season, and many households in the study region decided to fatten cattle for sale as prices are usually high for the festival. In all three areas cattle were moved to higher ground including schools and embankments and remained there for up to a month, until the homesteads dried up. Nevertheless, 19 of the households lost cattle in the 2016 floods. In 2017 fewer households could raise cash from livestock sale. Eid-

ul-Azha was about ten days earlier, and after the 2016 flood experience households either sold animals in advance of the flood season, to avoid potential losses, or they had fewer animals because they had been unable to replace the livestock they lost in 2016. Overall views regarding livestock as a coping mechanism were mixed.

Partly as a result of this cumulated loss of assets, the incidence of borrowing increased in 2017. Households borrowed money mainly from relatives and NGOs in 2016, but in 2017 25% of surveyed households borrowed from moneylenders suggesting that family sources had been exhausted. Limited support from NGO micro-credit services may be because NGOs are unwilling to operate typical savings and loan programmes in areas prone to erosion where households often move.

Compared with the other strategies, migration was quite widely reported as part of coping strategies, and is discussed in detail in section 3.4. In addition to being a component of livelihood strategies, in 2016 30-40% of the surveyed households said that household members undertook migration for work specifically to cope with flooding when no work was available locally, increasing to 50-70% of households in 2017.

The same broader elements of coping and resilience were considered by respondents to be important in all three unions in both years. They emphasised social capital in the form of help from relatives and neighbours, the availability of physical capital such as embankments for taking shelter, keeping livestock as a movable and saleable asset, and having savings. In addition, mobile phones were widely considered useful, for example to contact relatives and arrange evacuation. In 2017 credit from moneylenders and shops was more common than in 2016, which is consistent with fewer households having saleable assets left and having reduced savings because of the 2016 floods. Data from two successive years of unusual floods therefore show a pattern of widespread loss of assets, coping by reduced food intake, and short-term evacuation.

3.3.2 Role of embankments

Many of the nine unions are located in char areas or on the river side of existing embankments and are not protected by embankments. Yet, with the exception of one union, embankments are relatively close. In six out of eight unions these embankments breached in 2016, raising questions about their effectiveness in protecting crops and settlements from floods. Nevertheless, embankments were evaluated as very important in the surveys - as places of refuge. In the focus groups in Lalmonirhat and Kurigram it was reported that many

households that lost their homes to erosion or had flooding inside their homes moved temporarily to find shelter on embankments. Participants in a focus group in Kurigram in 2016 reported that: “Most people moved temporarily to embankment. …. These are very crowded places, some people even do not get space for sleeping. Due to mosquitoes and lack of clean drinking water we fell sick. For women latrine is a problem. Some NGOs helped people to raise land where they could stay. Some people lived on boats. Cooking food is a problem for lack of dry fuel and space. We could only cook once in a day. Getting work is a problem.” Thus although embankments provide a safe shelter for char people, there are also many difficulties faced by people taking shelter on embankments, which explain why they are mostly used short term until people can return to their homes.

The situation in Gaibandha is more complex, here several surveyed households already lived on the embankment, having previously lost their homes to erosion, but the embankment is itself threatened by erosion. Participants in a focus group here in 2016 said: “Embankment is already inhabited by people and crowded. During flood when we want to move there a clash happens due to lack of drinking water and sanitation. People move with livestock which ruins the soft shoulders of the embankment. Ultimately breach happens when the water current increases during high monsoon.” Thus the embankment here had already become more than a short-term destination for char people displaced by erosion, and evacuees are well aware that their actions con compromise the functioning of embankments. Because the embankment was already crowded, in Gaibandha those households that were flooded in 2016 evacuated to other high land and public buildings. However, in 2017 about half of the surveyed households in this area were able to squeeze onto embankments for shelter. The opinion of people in Gaibandha about the importance of embankments reflects this change. In 2016 they asserted that embankments were not of use to them because they get no help there and have to make their own home and get no services; but a year later they recognised the value of embankments for shelter. Overall, embankments contribute substantially to resilience since they help households remain in the riverine landscape.

3.3.3 Role of collective action

Another key element of coping strategies is social capital in the form of trusted relatives and neighbours. This social capital was strengthened to some extent by community based organisations (CBOs): local voluntary associations of households formally registered with government. Formed with the help of various past projects, they enable member households to cooperate to improve their livelihoods through water, agriculture and/or fishery

management. None were formed specifically to provide hazard related services. However, in Gaibandha, for example, in all three unions the CBOs formed a basis for voluntary assistance by helping to warn and rescue people, and contributing some materials for the worst affected. The CBOs differ in their capacities and services in floods, but even those with limited capacity contributed to resilience. For example, the leader of Konai Brahmaputra CBO, which was formed in Gaibandha in the early 2000s for fishery management, said in 2016: “Our members are very poor. Most of them fish for a living. But we helped people to move and when needed members helped each other to build shacks. Members collected bamboo from whoever had a bamboo grove for house rebuilding on the embankments.” CBOs differ from NGOs which are formed by one or a few individuals to provide services to target people, but CBOs formed a link with NGOs and other government agencies that supported flood warning dissemination through community volunteers.

In the study areas in Kurigram and Lalmonirhat, because the CBOs are federations with links to NGOs they have relatively wide coverage and put a priority on disaster risk reduction related activities. In the focus group discussions, CBOs were said to have played important local roles. For example, the leader of Satata Rajapur Federation in Lalmonirhat explained that “One of the main activities of our CBO is disaster management. The CBO members received training and formed volunteer group. We gave early warning through our own miking [loudspeaker] system. We relocate people by using members boats, and find out space for people and their livestock to move. We report to RDRS [a regional NGO] for relief and help. Also keep contact with government departments for rehabilitation, and cooperate with Union Parisad during relief distribution.” In Gaibandha externally based NGOs, rather than CBOs, provided similar services of general advice and flood warning systems with community volunteers in two areas. In Gaibandha the most erosion-prone union, NGOs (mainly the NGO Practical Action) helped people to move house, raise house plinths and establish new homes, and provided free replacement cattle.

In one union in Kurigram no NGO or government assistance was available. Despite almost all houses being flooded people did not move away and reported little damage. Here the CBO helped to warn people and move some vulnerable households. In the other two unions in this district CBOs also helped people to move and rebuild or repair their houses, and also formed a link with NGOs and government to access relief for those worst affected by erosion or floods.

3.4 Migration in 2016 and 2017

There are several ways of categorizing household movements and the relationship between these decisions and flood and erosion hazards. The distinction between temporary evacuation and a permanent move can be fuzzy, since households may evacuate when they are flooded, only to find their homestead land has eroded and then they either remain for a longer period living on embankments or make a house on other available land, often in the same area. Also, longer-term migration often only applies to one person in the household, who migrates for work 'seasonally' but often for a substantial part of the year.

3.4.1 Evacuation and longer-term shifts in residence

Many flooded households evacuated temporarily to safer locations. All households traced in 2017 evacuated, and almost all evacuated in 2016 (Table 3), except for Gaibandha where already some of the households lived on the embankment. Embankments and villages protected by embankments were the main evacuation destinations, although in 2016 fewer people moved to embankments in Gaibandha because they already had many households living there from previous displacement. Moreover, 25% of households that evacuated their homes in 2016 had to do this twice, and in 2017 58% of households that evacuated did this twice. In Lalmonirhat in 2016 evacuation was mainly for 1-5 days along the Teesta River, and for 6-10 days for the first event and an additional 16-30 days for those households that evacuated twice along the Brahmaputra-Jamuna River. There was a similar pattern in 2017 in the three areas of brief evacuation in the first flood peak and evacuation for 11-30 days in the second flood peak.

Permanent movement in the 2016 and 2017 floods was a response to erosion of homes and was short distance usually to embankments or other nearby places in order to stay close to relatives and be on hand for land possibly re-emerging from the river. Hence most households keep a physical and social base in the riverine landscape (on embankments, behind them, or in unprotected areas) according to opportunities and social links.

In all three districts people who evacuated in the 2016 and 2017 considered social capital in the form of relatives and other known and trusted people was the main advantage of living in their home locations compared with relocation places (Table 4). Resilience was also strengthened by similarly affected households cooperating and moving together (for example with CBO help). Safety, communications, productive land, and availability of land were highlighted as advantages of home areas. The main reported disadvantage of their home

location, especially in 2017 in all locations, was the risk there followed by a lack of work opportunities.

Whether movements should be seen as temporary evacuation or longer term is debatable. In many cases the households moved back to their homes shortly after the floods, but in other cases due to changes in the river and char morphology they remained for longer in 'temporary' places, expecting that their land might become inhabitable. In 2017 12% of the households surveyed in 2016 left the area and were untraceable, they were reported by former neighbours to have left permanently (with the highest emigration from Lalmonirhat, and lowest from Kurigram).

3.4.2 Seasonal migration for work

Seasonal migration for work is an important part of livelihood strategies for almost 70% of households surveyed: (highest incidence in Kurigram, lowest incidence - half of households in Lalmonirhat). Migration is reported to be increasing as a way of earning money to cope after floods. Migration for work mostly involved one man per household aged 16-40 with little or no education, hardly any women migrate for work. They moved either to cities and their edges (mostly Dhaka but also from Lalmonirhat to towns in neighbouring districts) for work in construction, labouring, pulling rickshaws, and rarely in factories; or to distant districts as teams/groups to plant and harvest crops during peak demand periods (notably from Kurigram to Munshiganj). Migration strategies are influenced by travel distance, contacts and opportunities. Migrants often move in groups and have built up personal contacts in destinations, which have been enhanced in the last decade by use of mobile phones. This 'seasonal migration' is for six or more months of the year, usually in several trips. Migrants commonly visit home at approximately monthly intervals. The lowest incidence of such migration was in July-August in both years when men came back to their villages to help their families cope in the flood season, and was high in the dry season and also in September-October as part of recovery after floods (Fig. 4).

Conditions faced by these migrants are difficult - they have no proper shelter, face poor sanitation and drinking water, and are vulnerable to exploitation in the cities. In focus groups with people involved in seasonal migration they highlighted the hardships involved, for example a participant in one focus group in Gaibandha said: "We go in a group and stay there until a specific job is finished. But getting work every day is uncertain. We have to work hard to earn money. Moreover, we are always worried about the family left at home. Sometimes people fall in a trap and get involved in drugs and other crime. Construction

labourers don't get wages on time and never get full payment. We all face water, sanitation, food and shelter problems. Besides we have to pay local mastans [musclemen] and police." Although such migration appears to improve coping and resilience, migrating men have to borrow to provide initial funds for their wives and families that remain behind, to cover travel costs, and to cover initial living costs when they move; all of which add new vulnerability and reduce the actual benefit received.

4 Discussion and Conclusions

The three districts and study locations selected for this study are representative of the socio-hydrological landscapes along the Brahmaputra-Jamuna River in Bangladesh, but the similarity of these areas with other locations along the main rivers, and the social linkages found with distant urban areas mean that the findings are of more general relevance. In the floods in 2016 and 2017, complex decisions on evacuation and longer-term movements were made by rural floodplain inhabitants. These decisions are not just a function of immediate flood and erosion impacts, or opportunities for shelter and for livelihoods nearby. Decisions were also found to be influenced, for example, by improved road communications that enable repeated trips to rapidly growing urban centres to take advantage of economic opportunities. Decisions are balanced by the risks and disadvantages of life in towns and cities. Hence migration of different types is no longer a last resort for flood-prone households.

Our study shows how households living in rural riverine areas make use of the socio-hydrological landscapes they inhabit, but also of enhanced physical and socio-economic connections to other landscapes including more distant urban areas:

- **Physically** they inhabit recently accreted and older floodplain lands that have high flood risks and where erosion forces frequent shifts of home, they also use the embankments that form the interface between local "unprotected" and "protected" socio-hydrological landscapes as temporary flood shelter, and for those affected by erosion as longer term shelter close to their lost land.
- **Economically** they use work opportunities in expanding urban areas and other districts to compensate for limited risky rural livelihoods in riverine areas.
- **Socially** they cooperate with others from their community informally and through community organisations to cope locally and to find work.

Living conditions in places of shelter (embankments, schools and other high places) were reported to be very difficult due to overcrowding, poor water and sanitation, and the difficulty of cooking. People from one char union preferred not to evacuate and instead stayed on boats or raised platforms to protect their homes. This local perspective highlights a difference between highly flood and erosion prone people regarding their use of the socio-hydrological landscapes compared with that of 'experts'. Water resource engineering in Bangladesh and elsewhere has conceived of structural flood mitigation in the shape of embankments to enable hazard-free livelihoods in the protected areas without considering use by people affected by floods and erosion. The normal engineering perspective is exemplified by a comment from a district level Bangladesh Water Development Board official in Kurigram.after the 2017 floods: "Embankments are mostly built for flood defence. In Bangladesh they are also meant to be used for transportation. However, when flood affected people move to embankment and make a permanent settlement there it becomes vulnerable to breaching, and that is what is happening here". This study shows how embankments are an important structural resource for resilience of inhabitants of the active floodplain and its riverine islands, even when they are breached or not continuous. Meanwhile embankments do not ensure a risk-free environment for inhabitants of protected areas because of frequent breaching, but they also provide places of shelter for inhabitants of the "protected" or "mainland" socio-hydrological landscape. This raises the question whether the government's structural responses to flood and erosion hazards considering the broader riverine landscape should focus on expensive rehabilitation, reinforcement and extension of embankments along the main rivers, or on other measures such as raised shelter areas above the level of exceptional floods. These raised shelter areas could be connected by moderately raised but flood resilient embankment-roads that would protect crops in 'normal' floods. Such alternatives deserve consideration by water resource engineers. Government programmes tend to treat socio-hydrological spaces, but if connections and migration were seen in more positively as a component of resilience costs saved from structural flood protection could, for example, be used to improve public services for urban migrants and for char communities.

Past studies on flood impacts and coping, such as Sultana and Rayhan (2012), have highlighted the importance of individual coping including borrowing and asset sales during and after floods. This study confirms how successive years of severe floods can erode personal assets accumulated over time and reveals how individual coping is complemented by social capital, and access to distant employment opportunities, which in turn is enhanced by urbanization. We find that temporary evacuation during floods as well as seasonal migration for work involves groups of households and individuals, who organise to exploit

these opportunities together. In addition to such informal arrangements, CBOs established for other purposes spontaneously responded to hazards and help local people to organise to improve their coping strategies. Examples of CBO initiatives included disseminating of warnings, helping people to evacuate, and helping displaced households to access relief services.

There is scope for CBOs, assisted by NGOs and government, to further help vulnerable households to work together to enhance their resilience. Whether seasonal migration is finally accepted by policy makers as part of a resilient rural livelihood strategy or not, CBOs might advocate better living conditions for migrants and help migrants to obtain better paid work. CBOs could also provide group loans to fund seasonal migration, including the living costs of families left in the riverine areas, on less exploitative terms than traditional money lenders. At the same time balanced collective action could help the women left behind when men migrate, women could organise in parallel groups to men in order to develop income sources and strengthen cooperation to protect their homes and families. These opportunities are enhanced by wider societal changes. Mobile phone technology now offers the scope for CBOs to improve information collection and distribution, and the flows of funds between households and their migrant workers.

If government and NGOs took a more integrated socio-hydrological perspective of riverine hazards and rural and urban linkages, this could pave the way to innovations that start from the perspective of rural inhabitants. This would help build longer term resilience to hazards that are likely to become more severe with climate change. Such an approach would involve technical and institutional changes such as designing embankments along main rivers that are more effective as flood shelters and improving water supply, sanitation and housing conditions for seasonal migrants in urban areas. The potential shown by local community organisations could be enabled to improve flood coping and resilience for mobile riverine households. Lastly the study showed how migration for work is a male phenomenon, revealing an opportunity to strengthen and improve cooperation among women for both hazard coping and resilient livelihoods that has so far been unaddressed.

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References

Ahsan, R., Karuppanan, S. & Kellett, J. (2014). Climate induced migration: lessons from Bangladesh. *The International Journal of Climate Change: Impact and Responses,* 5(2), 1-15.

Alamgir, M. (1980). *Famine in South Asia: Political economy of mass starvation*. Cambridge, MA.: Oelgeschlager, Gunn & Hain.

Auerbach, L.W., Goodbred, S.L., Mondal, D.R., Wilson, C.A., Ahmed, K.R., Roy, K., Steckler, M.S., Small, C., Gilligan, J.M. & Ackerly, B.A. (2015). Flood risk of natural and embanked landscapes on the Ganges-Brahmaputra tidal delta plain. *Nature Climate Change*, 5,153–157.

Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., & Warner, K. (2016). A people-centred perspective on climate change, environmental stress, and livelihood resilience in Bangladesh. *Sustainability Science*, 11(4), 679-694.

Baqee, A. (1998). *Peopling in the land of Allah jaane. Power, peopling and environment: the case of char-lands of Bangladesh*. Dhaka: The University Press.

Berkes, F. & Folke, C. eds. (1998). *Linking social and ecological systems: management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press.

Brammer, H. (1990). Floods in Bangladesh: Geographical background to the 1987 and 1988 floods. *The Geographic Journal*, 156(1), 12–22.

Brammer, H. (2004). *Can Bangladesh be protected from floods?* Dhaka: University Press.

Brammer, H. (2014). Bangladesh's dynamic coastal regions and sea-level rise. *Climate Risk Management,* 1, 51–62

Brouwer, R., Akter, S., Brander, L, & Haque, E. (2007). Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. *Risk Analysis*, 27(2), 313-326.

Dewan, C., Mukherji, A., & Buisson, M.C. (2015). Evolution of water management in coastal Bangladesh: From temporary earthen embankments to depoliticized community-managed polders. *Water International*, 40, 401–416.

EGIS (2000). *Riverine chars in Bangladesh environmental dynamics and management issues*. Dhaka: Environment and GIS Support Project for Water Sector Planning (EGIS) and The University Press Limited.

Elahi, K., Ahmed, K.S. and Mafizuddin, M. (1991). *Riverbank erosion, flood and population displacement in Bangladesh*. Jahangirnagar University Riverbank Erosion Impact Study, Dhaka.

Etzold, B., Ahmed, A.U., Hassan, S.R., & Neelormi, S. (2014). Clouds gather in the sky, but no rain falls: Vulnerability to rainfall variability and food insecurity in Northern Bangladesh and its effects on migration. *Climate and Development*, 6(1), 18-27.

Ferdous, M.R., Wesselink, A., Brandimarte, L., Slager, K., Zwarteveen, M., & Di Baldassarre, G. (2018). Socio-hydrological spaces in the Jamuna River floodplain in Bangladesh. *Hydrology and Earth System Science*, 22, 5159-5173.

Foresight (2011) *Migration and Global Environmental Change.* London: The Government Office for Science.

Gray, C. L., & Mueller, V. (2012). Natural disasters and population mobility in Bangladesh. *Proceedings of the National Academy of Sciences*, 109(16), 6000-6005.

Haque, C.E. (1988). Human adjustments to river bank erosion hazard in the Jamuna floodplain, Bangladesh. *Human Ecology,* 16(4), 421–437.

Haque, C. E., & Zaman, M.Q. (1993). Human Responses to Riverine Hazards in Bangladesh: A Proposal for Sustainable Floodplain Development. *World Development*, 21(1), 93-10.

Hutton, D., & Haque, C. E. (2004): Human vulnerability, dislocation and resettlement: adaptation processes of river-bank erosion-induced displacees in Bangladesh. *Disasters*, 28(1), 41-62.

Indra, D. (2000): Not just dis-placed and poor: How environmentally forced migrants in rural Bangladesh recreate space and place under trying conditions. *Rethinking refuge and displacement: Selected papers of refugees and immigrants*, 8, 163-191.

Islam, A.K.M.S. (2016). Aspects of 2016 flooding in Bangladesh. *New Age*, August 5, 2016.

Islam, M. S., Hasan, T., Chowdhury, M. S. I. R., Rahaman, M. H., & Tusher, T. R. (2012): Coping techniques of local people to flood and river erosion in char areas of Bangladesh. *Journal of Environmental Science and Natural Resources*, 5(2), 251-261.

Joarder, Md. A. M. & Miller, P.W. (2013). Factors affecting whether environmental migration is temporary or permanent: evidence from Bangladesh. *Global Environmental Change*, 23, 1511–1524.

Linton J. (2008). Is the hydrologic cycle sustainable? A historical-geographical critique of a modern concept. *Annals of the Association of American Geographers*, 98(3), 630-649.

Mamun, M. Z. (1996): Awareness, preparedness and adjustment measures of river-bank erosion-prone people: A case study. *Disasters*, 20(1), 68-74.

Ministry of Water Resources. (2001). Guidelines for Participatory Water Management. Dhaka: Ministry of Water Resources, Government of the People's Republic of Bangladesh

Mirza, M. M. Q. 2002. Global warming and changes in the probability of occurrence of floods in Bangladesh and implications. *Global Environmental Change*, 12(2), 127-138.

Paul, B. K. (1997): Flood research in Bangladesh in retrospect and prospect: a review. *Geoforum*, 28(2), 121-131.

Penning-Rowsell, E., Sultana, P. & Thompson, P. (2013). The 'last resort'? Population movement in response to climate-related hazards in Bangladesh. *Environmental Science & Policy (*2013), pp. 44-59.

Rahman, M. R. (2010): Impact of riverbank erosion hazard in the Jamuna floodplain areas in Bangladesh. *Journal of Science Foundation*, 8(1-2), 55-65.

Salauddin, M. & Ashikuzzaman, M. (2011). Nature and extent of population displacement due to climate change-triggered disasters in the south-western coastal region of Bangladesh. *Management of Environmental Quality*, 22(5), 620-631.

Sivapalan, M., Savenije, H. H. G., & Blöschl, G. (2012). Sociohydrology: A new science of people and water. *Hydrol. Process*., 26, 1270–1276.

Sjoukje, P., Sparrow, S., Kew, S.F., van der Wiel, K., Wanders, N., Singh, R., Hassan, A., Mohammed, K., Javid, H., Haustein, K., Otto, F.E.L., Hirpa, F., Rimi, R.H., Islam, A.K.M.S., Wallom, D.C.H., & van Oldenborgh, G.J. (2018). Attributing the 2017 Bangladesh floods from meteorological and hydrological perspectives. *Hydrol. Earth Syst. Sci. Discuss.*, https://doi.org/10.5194/hess-2018-379.

Sultana, N. & Rayhan, M.I. (2012). Coping strategies with floods in Bangladesh: an empirical study. *Natural Hazards*, 64(2), 1209-1218.

Sultana, P, Johnson, C. & Thompson, P. (2008). The impact of major floods on flood policy evolution: insights from Bangladesh. *International Journal of River Basin Management* 6(special issue), 1-10.

Sultana, P. & Thompson, P.M. (2010). Local institutions for floodplain management in Bangladesh and the influence of the Flood Action Plan. *Environmental Hazards*, 9(1), 26-42.

Thompson, P., & Tod, I. (1998). Mitigating flood losses in the active floodplains of Bangladesh. *Disaster Prevention and Management: An International Journal*, 7(2), 113-123.

Thompson, P.M. & Sultana, P. (2000). Shortcomings of Flood Embankment Strategies in Bangladesh. p 316-333. In D.J. Parker (ed.) *Floods* (vol. 1). London: Routledge.

Wesselink, A., Kooy, M., & Warner, J. (2017). Socio-hydrology and hydrosocial analysis?: toward dialogues across disciplines, *WIREs Water*, 4, 1–14, https://doi.org/10.1002/wat2.1196.

Yasmin T. & Ahmed, K. M. (2013). The comparative analysis of coping in two different vulnerable areas in Bangladesh. *International Journal of Scientific and Technology Research*, 2(8), 26-38.

Yu, D. J., N. Sangwan, K. Sung, X. Chen, & Merwade, V. (2017). Incorporating institutions and collective action into a sociohydrological model of flood resilience. *Water Resources. Research*, 53(2), 1336-1353.

Table 1 Reported health effects of 2016and 2017 floods

	2016			2017		
	Lalmonirhat (Rajpur)	Gaibandha (Kapasia)	Kurigram (Jatrapur)	Lalmonirhat (Rajpur)	Gaibandha (Kapasia)	Kurigram (Jatrapur)
Number of households reporting illness	22	33	28	27	31	22
% households affected	55	83	70	68	78	55
Number of persons	27	45	34	44	43	37
Days income loss from illness per affected household	6.0	11.8	16.5	6.9	25.2	13.6
Cost of treatment (Tk per person)	461	1,379	2,381	922	2,563	3,888
Cost of treatment (Tk per household)	565	1,880	2,891	922	3,555	6,539

Note: Tk = Bangladesh Taka, approximately Tk 82 = US$1 in these years

Table 2 Numbers of surveyed households involved in different types of movement in 2016 and 2017

District	2016				2017					
	Temporary Evacuation		Seasonal (for work)		Temporary Evacuation		Permanent move		Seasonal (for work)	
	no	%	no	%	no	%	no	%	no	%
Lalmonirhat (Rajpur)	39	97.5	22	55.0	34	100	6	15.0	14	41.2
Gaibandha (Kapasia)	28	70.0	27	82.5	36	100	4	10.0	23	63.9
Kurigram (Jatrapur)	39	97.5	30	75.0	37	100	3	7.5	27	73.0
Total	106	88.3	85	70.8	107	100	13	10.8	64	59.8

Percentages are out of sample size of 40 households in each district in 2016, but in 2017 are calculated out of those 107 households remaining

Table 3 Percentage of sample households evacuating in floods by origin and destination

Location	Lalmonirhat (Rajpur)		Gaibandha (Kapasia)		Kurigram (Jatrapur)	
	2016	2017	2016	2017	2016	2017
N=	39	35	28	36	39	37
Origin (place evacuated from)						
Island char	15.4	17.1	0.0	44.4	94.9	40.5
Riverside (not protected)	10.3	42.9	92.9	52.8	0.0	16.2
On embankment	0.0	2.9	3.6	2.8	0.0	0.0
Village area behind embankment	74.4	37.1	3.6	0.0	5.1	43.2
Destination (place evacuated to)						
Island char	2.6	2.9	3.6	0.0	0.0	0.0
Riverside (not protected)	0.0	2.9	46.4	0.0	0.0	0.0
On embankment	69.2	41.2	3.6	50.0	87.2	97.3
Village area behind embankment	25.6	44.1	46.4	50.0	10.3	0.0
Other more distant rural area	2.6	8.8	0.0	0.0	2.6	2.7

Table 4 Main advantages and disadvantages reported for home location (% of households)

Attribute	Lalmonirhat (Rajpur)		Gaibandha (Kapasia)		Kurigram (Jatrapur)		All	
	2016	2017	2016	2017	2016	2017	2016	2017
Advantages								
Relatives and known people	38.5	54.3	46.4	50.0	38.5	64.9	41.1	56.5
Safe location	5.1	28.6	28.6	19.4	25.6	37.8	19.8	28.7
Good communications	12.8	20.0	21.4	36.1	12.8	13.5	15.7	23.1
Productive land	23.1	28.6	7.1	5.6	23.1	13.5	17.8	15.7
Land to live on	2.6	17.1	7.1	38.9	0.0	21.6	3.2	25.9
Good public services (e.g. school, health)	12.8	14.3	3.6	13.9	10.3	10.8	8.9	13.0
Good environment	7.7	5.7	3.6	0.0	12.8	5.4	8.0	3.7
Plenty of work	7.7	11.4	0.0	13.9	0.0	2.7	2.6	9.3
Disadvantages								
Risky location	7.7	42.9	21.4	58.3	30.0	54.1	19.7	51.9
Little work	10.3	34.3	7.1	30.6	7.5	35.1	9.1	33.3
Poor communications	28.2	22.9	7.1	13.9	32.5	16.2	22.6	17.6
Theft/crime/tolls	7.7	25.7	21.4	27.8	2.5	5.4	10.5	19.4
Poor public services (e.g. school, health)	2.6	17.1	0.0	11.1	10.0	27.0	4.2	18.5
No/poor sanitation	2.6	14.3	14.3	19.4	15.0	5.4	10.6	13.0
Poor environment	2.6	2.9	0.0	16.7	2.5	10.8	1.7	10.2
Unproductive land	0.0	5.7	0.0	8.3	2.6	16.2	0.9	10.2
No land to live on	0.0	2.9	0.0	11.1	2.5	8.1	0.8	7.4
People not helpful	0.0	5.7	0.0	8.3	2.5	0.0	0.8	4.6

Note: multiple responses possible so each % is from those surveyed

Figures

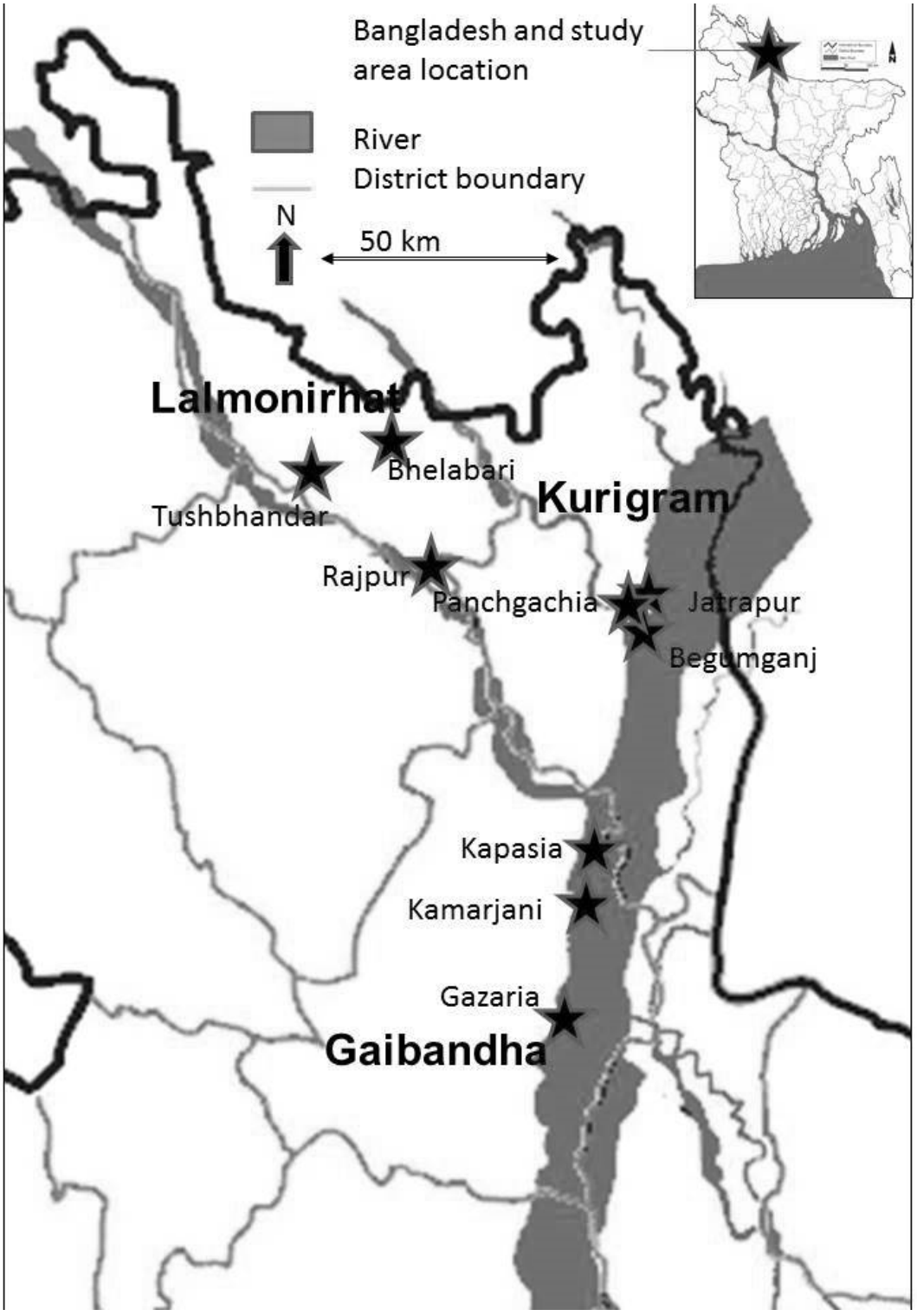

Fig. 1 Locations of study sites

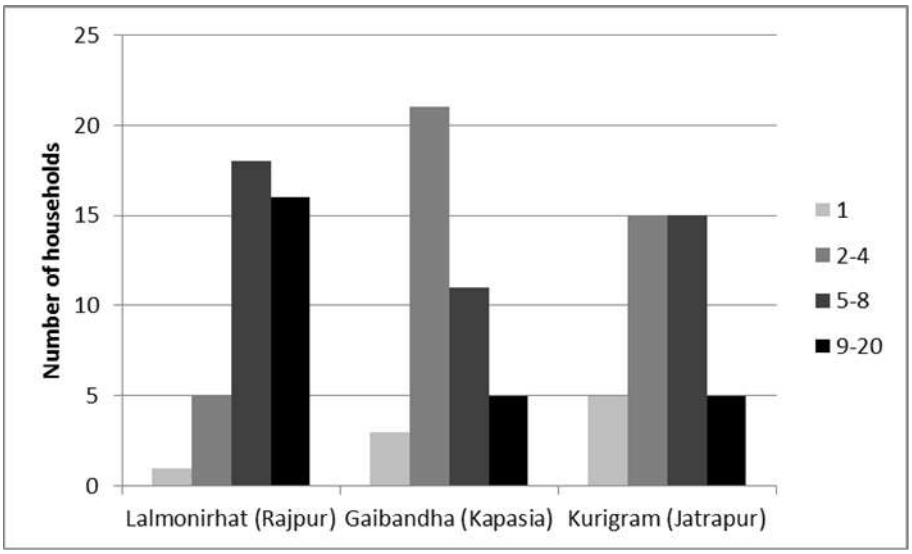

Fig. 2 Number of times respondents moved home in their lifetime

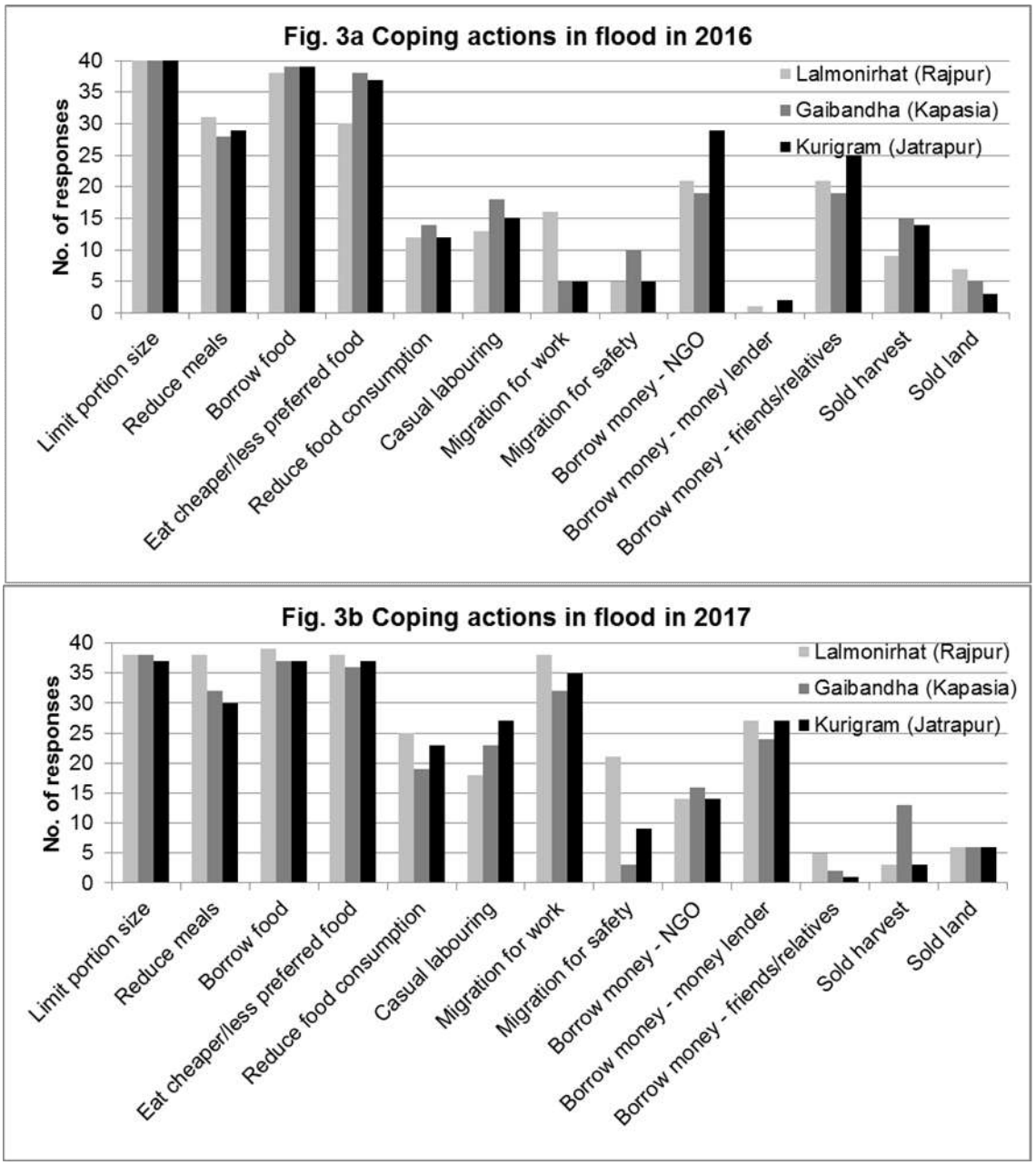

Fig. 3 Coping actions

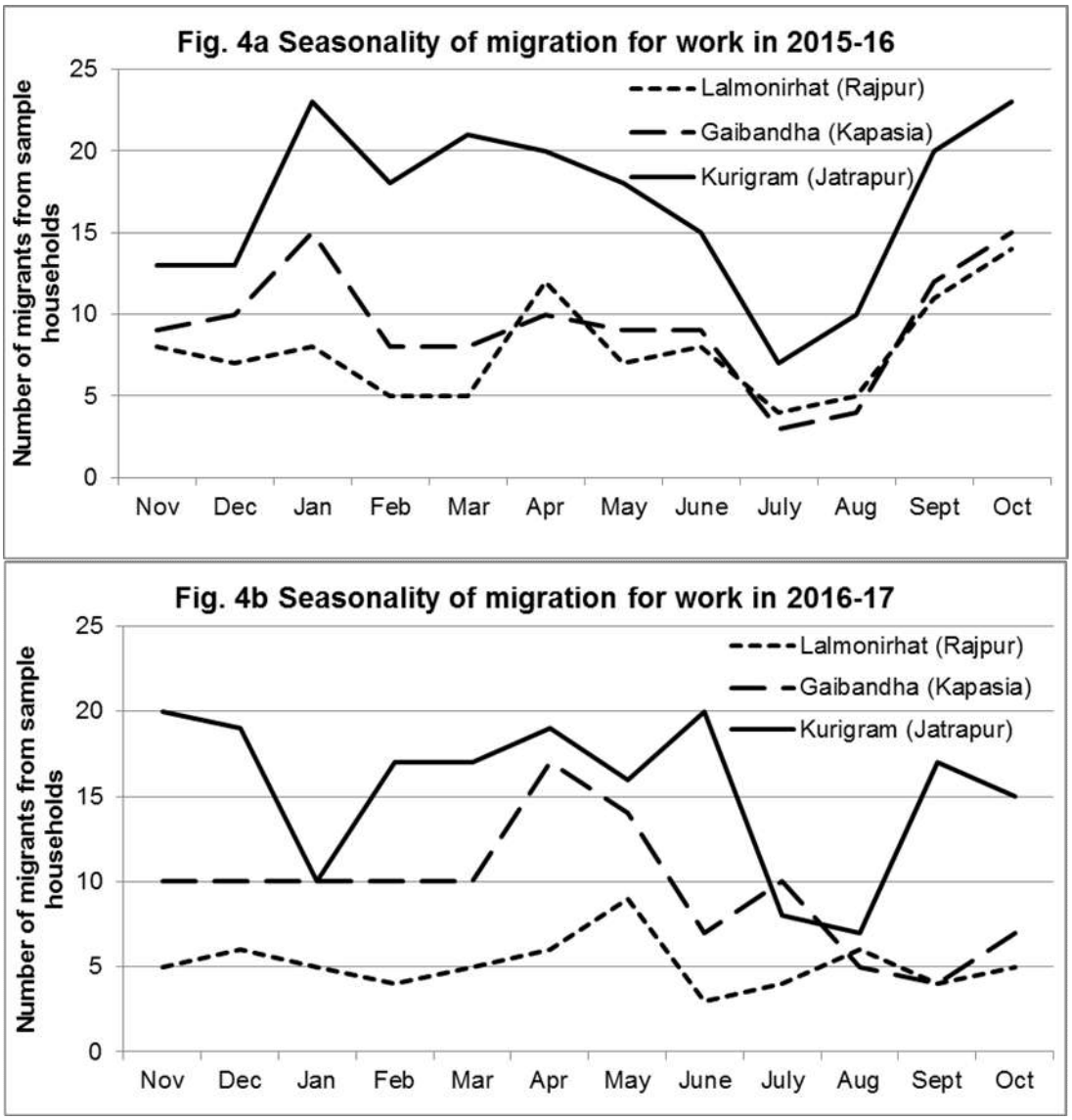

Fig. 4 Seasonality of migration for work

[i] The river known as the Brahmaputra in India continues to be known by that name in Bangladesh as far as the southern tip of Kurigram District, but further downstream is called the Jamuna River. The former course of the river (now a minor off-shoot to the east) continues to be named the (Old) Brahmaputra River.